CLAIMS:

I claim:

1. A system for detecting errors in a printed copy, the system comprising:

one or more computer memories having one or more digitized source images;

one or more scanners that scan one or more printed copies to create one or more corresponding scanned images;

an alignment process that creates an initial replacement image from the scanned image, the replacement scanned image being aligned with the digitized source image on a page by page, line by line, and pel by pel basis; and

a comparison process that compares one or more source pels of the digitized source image with one or more corresponding scanned pels of the initial replacement image to determine differences, the differences being defects in the printed copies.

2. A system for detecting errors in a printed copy, the system comprising:

one or more computer memories having one or more digitized source images;

a digital printer that converts the digitized source images into one or more printed copies;

one or more scanners that scan the printed copies to create one or more corresponding scanned images;

an alignment process creates a replacement image from the scanned image, the replacement image being aligned with the digitized source image on a page and page, line by line, and pel by pel basis; and

a comparison process that compares one or more source pels of the digitized source image with one or more corresponding scanned pels of the replacement image to determine differences, the differences being defects in the printed copies.

3. A system, as in claim 2, where the alignment process comprises a course alignment and a subsequent fine alignment.

4. A system, as in claim 3, where the course alignment produces an initial replacement image and the fine alignment produces a final replacement image being the replacement image.

5. A system, as in claim 3, where the course alignment is a repeated application of an affine transform of source image pels and the fine alignment is a repeated application of a one dimensional cross-correlation of one or more course aligned pels to source pels.

6. A system, as in claim 2, where the alignment process comprises the steps of:

embedding two or more vertical synchronization-strips into the digitized source image;

printing the synchronization-strips on the printed copy;

scanning the printed copy so that two or more scanned vertical synchronization-strips are embedded in the scan copy, the vertical synchronization-strips being separated by a first separation distance;

tracking the horizontal and vertical coordinates of one or more sequential and specifically identifiable features in lines of the synchronization-strip to create a line by line correspondence between the source image and the corresponding scanned image;

performing a scanned image pixel value interpolation based on an affine transform, comprising the following steps:

sub dividing the source image and scanned image into one or more source and scanned horizontal strips, respectively;

determining at least two corresponding points on two corresponding lines in the source and scanned images, the two corresponding lines separated by a second separation distance;

using at least four of the corresponding points, two at a time from each of the lines to develop a transformation of the coordinates of pels in the source image to points of interest in the scanned image;

determining an interpolated pixel value of the scanned image at the point of interest; and

for each pixel, placing the interpolated pixel value into an initial replacement image at the pel coordinates corresponding to the pel of the source image used to determine the point of interest.

7. A system, as in claim 6, where the alignment process further comprises the steps of:

dividing the source image into a plurality of initial source horizontal strips;

dividing one of the source horizontal strips into a plurality of source vertical stripes;

dividing the initial aligned image into a plurality of initial aligned horizontal strips;

dividing one of the aligned horizontal strips into a plurality of initial vertical stripes;

dividing the initial horizontal strip corresponding to the respective source horizontal strips into a plurality of initial vertical stripes, the source vertical stripes and the initial vertical strips corresponding to one another and having the same height and width;

determining three or more cross-correlation values between the source and initial vertical stripes for an initial horizontal alignment and two or more horizontal offsets between the source and initial vertical stripes;

using the three or more cross-correlation values and their corresponding offsets to further determine an interpolated offset that produce the optimal correlation value;

producing an interpolated offset for each pair of source and initial vertical stripes;

performing a piece-wise interpolation between the interpolated offsets to develop a fine alignment that is dependent on the horizontal pel position of the source image; and

re-performing the scanned image pixel value interpolation wherein a horizontal coordinate of the pel of the source image is increased by the piece-wise interpolated value of the fine alignment.

8. A system, as in claim 2, where the comparison process uses masks.

9. A system, as in claim 8, where the mask is a dilation mask.

10. A system, as in claim 8, where the mask is an erosion mask.

11. A system, as in claim 2, where the comparison process comprises the steps of:

dilating the source image;

eroding the replacement image;

bit-wise ***or***'ing the corresponding one-bit pel values of the dilated source image and the eroded replacement image to produce a first intermediate result;

bit-wise ***exclusive-or***'ing the first intermediate result with the one-bit pel values of the dilated source image to indicate the pel locations of excess ink in the scanned image.

12. A system, as in claim 11, where the comparison process further comprises the step of:

declaring a defect only if two or more adjacent pel locations have an excess of ink.

13. A system, as in claim 12, where the defect is declared in at least one of the following situations: two or more horizontally adjacent pel locations have an excess of ink, two or more vertical adjacent pel locations have an excess of ink, and two or more horizontally adjacent and two or more vertical adjacent pel locations have an excess of ink.

14. A system, as in claim 2, where the comparison process comprises the steps of:

dilating the replacement image;

eroding the source image;

bit-wise ***and***'ing the corresponding one-bit pel values of the dilated replacement image and the eroded source image to produce a second intermediate result;

bit-wise ***exclusive-or***'ing the second intermediate result with the one-bit pel values of the eroded source image to indicate the pel locations of missing ink in the scanned image.

15. A system, as in claim 14, where the comparison process further comprises the step of:

declaring a defect only if two or more adjacent pel locations are missing ink.

16. A system, as in claim 14, where the defect is declared in at least one of the following situations: two or more horizontally adjacent pel locations are missing ink, two or more vertical adjacent pel locations are missing ink, and two or more horizontally adjacent and two or more vertical adjacent pel locations are missing ink.

17. A system, as in claim 2, where the comparison process comprises the steps of:

thresholding and dilating the source image;

thresholding and eroding the replacement image;

bit-wise ***or***'ing the corresponding pel values of the dilated source image and the eroded replacement image to produce a first intermediate result;

bit-wise ***exclusive-or***'ing the first intermediate result with the dilated source image to indicate the pel locations of excess ink and stray marks in the scanned image.

18. A system, as in claim 17, where the threshold is any one of the following percentage of the initial pixel values: 5% - 95%, 25%, and 50%.

19. A system, as in claim 2, where the comparison process comprises the steps of:

thresholding and dilating the replacement image;

thresholding and eroding the source image;

bit-wise ***and***'ing the corresponding pel values of the dilated replacement image and the eroded source image to produce a second intermediate result;

bit-wise ***exclusive-or***'ing the second intermediate result with the eroded source image to indicate the pel locations of missing ink in the scanned image.

20. A system, as in claim 19, where the threshold is any one of the following percentage of the initial pixel values: 5% - 95%, 25%, and 50%.

21. A system, as in claim 2, where the scanner has a line array sensor.

22. A system, as in claim 21, where the line array sensor is compensated so that all pixels that sense only black ink printed on paper produce the same black numeric value and that all pixels that sense blank paper produce the same white numeric value.

23. A method for aligning content on a printed page, the method comprising the steps of:

embedding two or more synchronization-strips into a digitized source image to form a marked source image; and

printing the marked source image to form a printed copy, the embedded synchronization-strips containing line identification of one or more lines of the printed copy.

24. A method, as in claim 23, further comprising the steps of:

scanning the printed copy so that two or more scanned vertical synchronization-strips are embedded in a scanned image, the vertical synchronization-strips being separated by a first separation distance; and

tracking the horizontal and vertical coordinates of one or more sequential and specifically identifiable features in the synchronization-strip to create a line by line correspondence between the marked source image and the corresponding scanned image.

25. A method, as in claim 24, further comprising the steps of:

performing a scanned image pixel value interpolation based on an affine transform, the affine transform comprising the following steps:

sub dividing the source image and scanned image into one or more source and scanned horizontal strips, respectively;

determining by synchronization-strip tracking at least two corresponding points on two corresponding lines in the source and scanned images, the two corresponding lines separated by a second separation distance;

using at least four of the corresponding points, two at a time from each of the lines to develop a transformation of the coordinates of pels in the source image to points of interest in the scanned image;

determining an interpolated pixel value of the scanned image at the point of interest; and

for each pixel, placing the interpolated pixel value into an initial replacement image at the pel coordinates corresponding to the pel of the source image used to determine the point of interest.

26. A system, as in claim 23, where the alignment process further comprises the steps of:

dividing the source image into a plurality of initial source horizontal strips;

dividing one of the source horizontal strips into a plurality of source vertical stripes;

dividing the initial aligned image into a plurality of initial aligned horizontal strips;

dividing one of the aligned horizontal strips into a plurality of initial vertical stripes;

dividing the initial horizontal strip corresponding to the respective source horizontal strips into a plurality of initial vertical stripes, the source vertical stripes and the initial vertical strips corresponding to one another and having the same height and width;

determining three or more cross-correlation values between the source and initial vertical stripes for an initial horizontal alignment and two or more horizontal offsets between the source and initial vertical stripes;

using the three or more cross-correlation values and their corresponding offsets to further determine an interpolated offset that produce the optimal correlation value;

producing an interpolated offset for each pair of source and initial vertical stripes;

performing a piece-wise interpolation between the interpolated offsets to develop a fine alignment that is dependent on the horizontal pel position of the source image; and

re-performing the scanned image pixel value interpolation wherein a horizontal coordinate of the pel of the source image is increased by the piece-wise interpolated value of the fine alignment.

27. A system for aligning content on a printed page, the system comprising:

means for embedding two or more synchronization-strips into a digitized source image to produce a marked source image; and

means for printing the marked source image containing the synchronization-strips on a printed copy, the synchronization-strips containing line identification of one or more lines of the printed copy.

28. A system for aligning content in a printed copy, the system comprising:

one or more scanners that scan one or more printed copies to create one or more corresponding digitized scanned images;

an alignment process that embeds two or more synchronization-strips into a digitized source image to produce a marked source image; and

printer that prints the marked source image with the embedded synchronization-strips to form the printed copy, the synchronization-strips containing line identification of one or more lines of the printed copy.

29. A system, as in claim 28, where the printer prints one or more of the synchronization-strips in any one or more of the following locations: in a vertical gutter between pages printed on a web segment and in a vertical sacrificial part of the web segment.